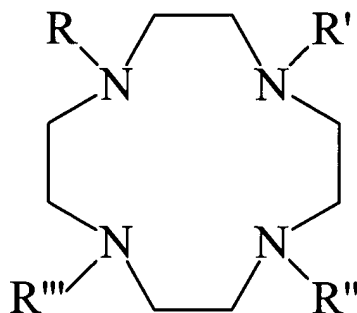


WHAT IS CLAIMED IS:

1. A contrast agent comprising:

a tetraazacyclododecane ligand having a general formula as follows:



wherein pendent arms R, R', R'' and R''' are amides having a general formula:  $-CR_1H-CO-NH-CH_2-R_2$ , wherein  $R_1$  includes organic substituents and  $R_2$  is not hydrogen; and

a paramagnetic metal ion coordinated to said tetraazacyclododecane ligand.

2. The contrast agent as recited in Claim 1 further including a water molecule associated with said tetraazacyclododecane ligand and said paramagnetic metal ion such that said water molecule has a  $\Delta\omega \cdot \tau_M \geq 1$ .

3. The contrast agent as recited in Claim 2 wherein said  $\Delta\omega \geq 6$  ppm.

4. The contrast agent as recited in Claim 2 wherein  
said  $\tau_M \geq 1 \mu s$ .

5. The contrast agent as recited in Claim 1 wherein said  
paramagnetic metal is selected from the group consisting of:

Eu<sup>3+</sup>;

Tb<sup>3+</sup>;

Dy<sup>3+</sup>; and

Ho<sup>3+</sup>.

6. The contrast agent as recited in Claim 1 wherein said  
paramagnetic metal is selected from the group consisting of:

Pr<sup>3+</sup>;

Nd<sup>3+</sup>;

Sm<sup>3+</sup>;

Er<sup>3+</sup>; and

Tm<sup>3+</sup>.

7. The contrast agent as recited in Claim 1 wherein said  
R<sub>2</sub> does not have a proton exchangeable group.

8. The contrast agent as recited in Claim 7 wherein said  
R<sub>2</sub> is selected from the group consisting of:

Alkyl groups having 20 carbon atoms or less;

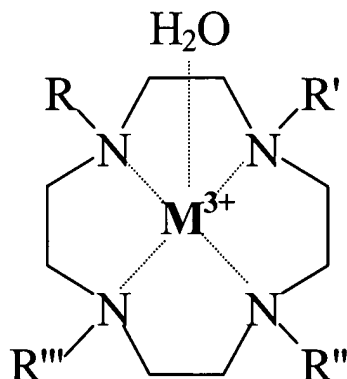
4 Cycloalkyl groups having 20 carbon atoms or less;  
5 Alkyloxy groups having 20 carbon atoms or less;  
6 Alkyl ethers having 10 oxygen atoms or less and 20 carbon  
7 atoms or less; and  
8 Polyols having 20 carbon atoms or less.

9. The contrast agent as recited in Claim 1 wherein said  
1 R<sub>1</sub> is selected from the group consisting of:

2 H;  
3 Alkyl groups having 20 carbon atoms or less;  
4 Cycloalkyl groups having 20 carbon atoms or less;  
5 Alkyloxy groups having 20 carbon atoms or less;  
6 Alkyl ethers having 10 oxygen atoms or less and 20 carbon  
7 atoms or less; and  
8 Polyols having 20 carbon atoms or less.

10. A method of using a magnetic resonance (MR) contrast agent, comprising:

subjecting a contrast agent contained within a sample to a radio frequency pulse wherein said contrast agent is a tetraazacyclododecane ligand having a general formula of:



wherein pendent arms  $R$ ,  $R'$ ,  $R''$  and  $R'''$  comprise organic substituents and said tetraazacyclododecane ligand further includes a paramagnetic metal ion ( $M^{3+}$ ) coordinated to said tetraazacyclododecane ligand and a water molecule ( $H_2O$ ) associated with said tetraazacyclododecane ligand; and

obtaining a magnetization transfer signal by applying a radio frequency pulse at a resonance frequency of said water molecule.

11. The method as recited in Claim 10 wherein said water molecule has a  $\Delta\omega \cdot \tau_M \geq 1$ .

12. The method as recited in Claim 10 further includes

2 producing a magnetization transfer magnetic resonance image from  
3 said magnetization transfer signal.

13. The method as recited in Claim 10 further includes  
2 applying said radio frequency pulse as a saturating pulse.

14. The method as recited in Claim 10 further includes  
2 said contrast agent with at least one pendent arm containing an  
3 amide group.

15. The method as recited in Claim 14 wherein said  
2 pendent arms are identical and have the general formula:  
3  $-\text{CHR}_1-\text{CO}-\text{NR}_2-\text{R}_3$ , wherein  $\text{R}_1$ ,  $\text{R}_2$  and  $\text{R}_3$  comprise organic  
4 substituents.

16. The method as recited in Claim 14 wherein said  
2  $\text{R}_1$  and  $\text{R}_2$  are H, and  $\text{R}_3$  has the general formula:  $-(\text{CH}_2)_n\text{COOR}_4$   
3 where

4  $n = 1-20$ ; and

5  $\text{R}_4$  is selected from the group consisting of:

6 H;

7 Group IA or IIA metal ions; and

8 alkyl groups containing from one to twenty Carbon  
9 atoms.

17. The method as recited in Claim 14 wherein said  
paramagnetic metal ion is selected from the group consisting of:

Tb<sup>3+</sup>;

Dy<sup>3+</sup>; and

Ho<sup>3+</sup>.

18. The method as recited in Claim 14 wherein said  
paramagnetic metal ion is selected from the group consisting of:

Eu<sup>3+</sup>;

Pr<sup>3+</sup>; and

Nd<sup>3+</sup>.

19. The method as recited in Claim 14 wherein said  
R<sub>1</sub> and R<sub>2</sub> are H, and R<sub>3</sub> has the general formula: -

(CH<sub>2</sub>)<sub>n</sub>P(O)(OR<sub>4</sub>OR<sub>5</sub>) where

n = 1-20;

said R<sub>4</sub> is selected from the group consisting of:

H;

alkaline earth metal ions of Groups IA or IIA; and

alkyl groups containing one to twenty Carbon atoms;

and said R<sub>5</sub> is selected from the group consisting of:

H;

alkaline earth metal ions of Groups IA or IIA; and

12 alkyl groups containing one to twenty Carbon atoms.

20. The method as recited in Claim 14 wherein said  
2  $R_1$  and  $R_2$  are H, and  $R_3$  has the general formula:  $-(CH_2)_nR_4$  where  
3  $n = 1-20$ ; and  
4  $R_4$  is selected from the group consisting of:  
5 Pyridine (Py); and  
6 Phenol (Ph).

21. The method as recited in Claim 14 wherein said  
2 pendent arms  $R$  and  $R''$  are identical, said pendent arms  $R'$  and  
3  $R'''$  are identical, and said pendent arms  $R'$  and  $R'''$  are not  
4 equal to said pendent arms  $R$  and  $R''$ .

22. The method as recited in Claim 21 wherein  
2 said pendent arms  $R$  and  $R''$  have the general formula:  
3  $-CR_1H-CO-NH-CH_2-R_2$ ; and  
4 said pendent arms  $R'$  and  $R'''$  have the general formula:  
5  $-CHR_3-CO-NH-R_4$  wherein  
6 said  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$  comprise organic substituents; and  
7  $R_2$  is not equal to  $R_4$ .

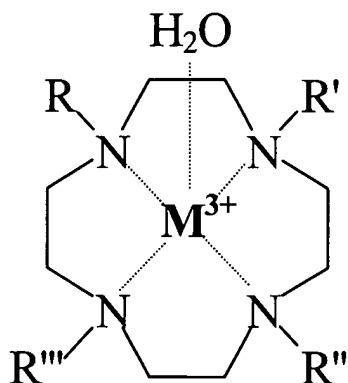
23. The method as recited in Claim 14 further  
2 includes obtaining said magnetization transfer signal by

3 applying a radio frequency pulse at a resonance frequency of  
4 said protons associated with said amide.

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24. A magnetic resonance system, comprising:

a magnetic resonance (MR) contrast agent, wherein said MR agent tetraazacyclododecane ligand, having a general formula of:



wherein pendent arms R, R', R'' and R''' comprise organic substituents and said tetraazacyclododecane ligand further includes a paramagnetic metal ion ( $\text{M}^{3+}$ ) coordinated to said tetraazacyclododecane ligand and a water molecule ( $\text{H}_2\text{O}$ ) associated with said tetraazacyclododecane ligand, wherein said MR contrast agent produces a magnetization transfer signal when subjected to a radio frequency pulse; and

a magnetic resonance apparatus configured to produce said frequency pulse.

25. The magnetic resonance system recited in Claim 24, further comprising a sample containing said MR contrast agent.

26. The magnetic resonance system recited in Claim 24, wherein said sample is a living subject.

27. The magnetic resonance system recited in Claim 24,  
2 wherein said magnetic resonance apparatus produces a  
3 magnetization transfer image of said sample from said  
4 magnetization transfer signal.

28. The magnetic resonance system recited in Claim 27,  
2 wherein said magnetic resonance apparatus produces said  
3 magnetization transfer image by applying said radio frequency  
4 pulse at a resonance frequency of said water molecule.

29. The magnetic resonance system recited in Claim 28,  
2 wherein said magnetic resonance apparatus produces a  
3 magnetization transfer difference image by applying said radio  
4 frequency pulse at a  $\Delta\omega$  of said water molecule, acquiring said  
5 magnetization transfer signal and subtracting said signal from a  
6 MR signal obtained by applying a radio frequency pulse at  $-\Delta\omega$ .

30. The magnetic resonance system recited in Claim 27,  
2 wherein said magnetic resonance apparatus produces said  
3 magnetization transfer image by applying said radio frequency  
4 pulse at a resonance frequency of protons associated with an  
5 amide included in one or more of said pendent arms.

31. The magnetic resonance system recited in Claim 24,  
2 wherein said radio frequency pulse is produced by said magnetic  
3 resonance apparatus and is a saturating pulse.

32. The magnetic resonance system recited in Claim 24,  
2 wherein said saturating pulse is applied at a resonance  
3 frequency of said water molecule.

33. The magnetic resonance system recited in Claim 24,  
2 wherein said saturating pulse ranges from about 1 to about 3  
3 seconds.

34. The magnetic resonance system recited in Claim 24  
2 wherein said water molecule has a  $\Delta\omega \cdot \tau_M \geq 1$ .

35. The magnetic resonance system recited in Claim 24  
2 wherein said  $\Delta\omega \geq 6$  ppm.

36. The magnetic resonance system recited in Claim 24  
2 wherein said  $\tau_M \geq 1 \mu s$ .